SECRET

MICROELECTRONICS PROGRAM PLAN

GOALS

The primary direction this program will follow is the development of suitable technology for implementing electronic functions with minimum prime power requirements. By definition, Micropower Electronics will be taken to be those electronics that operate at the minimum absolute power supply level and/or those electronics that operate with maximum efficiency. Efficiency in this context is defined as the ratio of functionally useful power to the absolute prime power supplied. For example, in the case of a transmitter, efficiency is that ratio of effective radiated power to total power drain from the prime power source. In the course of developing the technology that supports micropower electronics, substantial effort is to be focused on fabrication methods and techniques, reproducibility, and long-term reliability. These considerations are of critical importance in accomplishing a smooth and timely transition of a given development into the hands of the user groups which obviously is the ultimate goal of this plan.

IMPLEMENTATION

Based on in-house analyses, basic research is supported in selected technical areas. Generally, the analyses have indicated specific components such as the transistor as the major impediment to attaining micropower operation. When this is the case, a development group is selected which not only has the research capability but ideally is also associated with a production operation as well. Experience has shown that this ideal case produces better results from a time and schedule viewpoint to say nothing of the reproducibility aspect. Research is then pursued with this group until such time that the desired goals are achieved in the laboratory. At this juncture, if the case is an ideal one, a small scale pilot production run is attempted to establish the data base for future fabrication runs. A second attribute of this pilot fabrication exercise is that it

[redacted]

produces small quantities of the product for analysis and evaluation by the research group and by the various potential users. Thus the user gains some advanced knowledge of emerging products that will influence his future plans, and preliminary reliability data can be gathered. Based on working out the details of the reproduction process, a manufacturing group is given the task of producing whatever quantity of the product is desired. If, for example, the item has commercial appeal, then the contractor will produce significant quantities and the long-term reliability will be gathered rather easily. On the other hand, if the item is peculiar to Agency requirements, an independent investigator is enlisted to attempt a long-term reliability analysis based on accelerated life tests, artificial aging, or whatever means are appropriate.

Clearly this procedure will vary somewhat depending upon the nature of the product itself. For example, if the item happens to be a transistor, a miniature isolator, or some other component, then the plan described above will closely describe its evolution. Alternatively, if the product happened to be a micropower circuit technique for oscillator stabilization, say, then the steps would be somewhat altered since the final item is not an identifiable entity in its own right.

CURRENT DEVELOPMENT EFFORTS

Low Voltage Transistors

The present emphasis has been placed on the UHF region of the RF spectrum with additional research in S-band. In the former case, the fabrication techniques needed for a pilot run of power transistors is being formulated. One such run is anticipated during the current project. Since the S-band transistor will build upon the technology and knowledge gained at UHF, the effort is research in nature with no pilot production forecast for this contract period.

Direct correlation between performance and fabrication techniques remains the highest priority data to be gathered because of the direct relationship with reliability and reproduction costs.

Micropower Circuit Techniques

Techniques are being developed for providing a tailored base characteristic as required for stabilization of bipolar devices over temperature and supply voltage variations. The emphasis in this endeavor is to compile a catalog of integrated resistor-transistor-diode network designs to fulfill this goal. A small sample will be fabricated for evaluation purposes; however, the major product will be the tabulation of designs versus desired characteristics.

Silicon on Insulating Substrate (SOIS)

SOIS process technology is being developed for use in the fabrication of low voltage digital functions. The results of this work are expected to increase the speed of current micropower digital circuitry, substantially reduce the power required, and reduce the cell size (the area required to fabricate a digital circuit). A sample circuit will be fabricated utilizing these techniques for evaluation purposes. Based on the results obtained, the basic technology will be incorporated into the fabrication process of micropower digital circuits currently in use to obtain the projected performance enhancement.

Linear Complementary-MOS (CMOS) Circuits

Basic research into the utility of linear CMOS circuits and devices is underway to assess applicability in micropower low frequency functions; i.e., audio amplifiers, operational amplifiers, and active filters. The potential of CMOS for more complete integration of linear functions and reduction in quantity/size of off-chip components is being investigated. These investigations will form the basis for future actions in this area.

Miniature Coupler

Analysis and experimentation are being performed to determine the utility of opto-electronic couplers as RF isolators at VHF frequencies. The investigation is addressing the problem of providing isolation between stages and/or between the output stage and the antenna of low power VHF transmitters. If successful in developing this concept, a sample quantity will most certainly be fabrication for in-house (ORD/TSD) evaluation.

Micropower Electronics Reliability Analysis

An analysis of micropower system reliability is being pursued to determine the failure mode and projected lifetime of such systems. Although the reliability figure of merit of several of the in-field micropower components is known on an individual basis, the data is missing from a total system viewpoint. What is to be ascertained is how the new micropower components interface with the standard items, whether system assembly is significantly affecting life, and what is the projected life of these specialized systems. The results will be documented in a report indicating possible weakness requiring future R&D and procurement procedures to enhance reliability.

Micropower Fabrication and Design Support

This area represents a laboratory geared to preliminary experimental analysis, independent evaluation of products and designs, and a rapid implementation vehicle for exploiting new developments. An extremely valuable attribute of this facility is the part it plays in providing the transition for technology from component R&D into user-oriented system concepts.

[redacted]

FUTURE DEVELOPMENT AREAS

Digital Frequency Control

The successful development of low voltage micropower Silicon Gate MOS digital functions has opened an entirely new field of command and control electronics. With microwatts of power, it is possible to dynamically tune receivers and transmitters. It is planned to implement one particular function to verify the design concept and provide the vehicle for demonstrating the utility of this technology to user groups. The general design concept is as unique as the technology supporting it and will be of prime import to TSD and OEL in particular. This developmental area undoubtedly will motivate the creative command and control designer to significantly upgrade all remotely controlled devices.

Large Scale Integration (LSI)

Beyond any question, the future of electronic system development belongs to those who have a viable capability in integrated circuit technology. To achieve the ultimate in reliability without giving up the versatility required of Agency requirements, a custom LSI facility must be cultivated. This group must, of course, be well-versed in current technology but not basic research oriented. Rather, it is desirable that their research must be directed toward developing the capability of generating medium-to-large scale integrated circuits using advanced technology (such as Silicon Gate MOS techniques, SOIS, etc.) in a short time frame. While there are a number of custom LSI laboratories presently operating, they basically use techniques and standards that are three-to-five years old. The plan of the micropower program will be to develop a source of LSI chips using the Silicon Gate MOS/SOIS technology and will ignore the current N,P channel MOS methods. The decision to proceed in this direction is based on both performance analysis and reliability factors which indicate that conventional technology has reached a practical limit. These LSI circuits will be, of course, specialized to Agency needs and requirements. Examples of these types of circuits that can be identified today are the 200K bit shift register for audio surveillance and the processing chips for the MICROLORAN concept. The development effort will focus primarily on processing and fabricating technology with functional requirements being derived from more mission-oriented endeavors.

Micropower Component Development

There exist a significant number of passive components that require and deserve R&D attention, particularly in the micropower regime. One is the isolator/coupler requirement which is currently being investigated under the basic research effort. The need for such item is beyond question; however, the realization is by no means clearly established. Basic research also needs to be carried out in the area of micro-power timing functions or crystal development. Electronic circuits that are crystal-controlled are difficult at higher power levels but practically untenable at reasonable power efficiencies. Current efforts in the research area have developed means and standards by which reasonably good devices may be selected (usually one out of 20) but no effort has been directed toward perfecting techniques for producing predictable units of good quality. Although only two items have been used as examples, they each represent a substantial effort in R&D that will not be pursued by groups outside the Agency. In general, to the extent that resources allow, the microelectronics companies will attempt to develop those components that appear the most critical to micropower operation. Some other examples that may be cited without discussion are low voltage tuning capacitors or diodes, low temperature co-efficient resistors and capacitors, micropower sensitors (positive temperature co-efficient resistive elements), and such other items that analysis shows to have become critical to successful operation.

Signal Sources

Present efforts are directed toward low voltage transistors up to and including S-band. However, the need can easily be identified for micropower devices (not necessarily transistors) at frequencies well into the tens-gigahertz frequency range. As the technology becomes available, emphasis will be shifted into these regions of the spectrum. At some point between 5 and 10 GHz, the conventional transistor will most likely disappear and bulk effects will begin to dominate. This line of investigation will follow upon completion of transistor developments which is by no means barren of fruitful developments.

Implications of Current Developments

It should be noted that the current research effort contains several potentially dramatic program areas. Ranging from processing technology such as SOIS to linear CMOS devices they span the spectrum. In the former case, successful development will undoubtedly go unobserved except in the enhanced performance of the micropower digital circuitry. In the latter case, however, an entirely new area of endeavor might be dictated. It is, of course, obvious that linear CMOS circuits are not alone in this category. Within the resources available, it is the plan of this program to continue to develop those components and others like them to the point where relative importance can be clearly defined by the user group such as TSD, OEL, and OC.